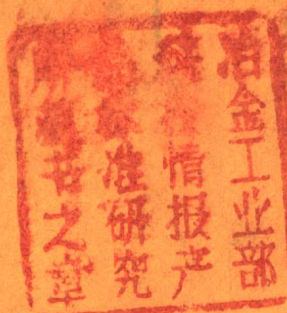


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# The World Energy Book

An A-Z, Atlas and Statistical  
Source Book

David Crabbe and Richard McBride





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Source Book**

*Consultant Editors and Principal Contributors*

**David Crabbe and Richard McBride**

*Open University Energy Research Group*



**Kogan Page**



*Contributors:*

Jennifer Clark, Michael Gabb, David Hemming,  
Norman Hill, Ray Oddy, Cyril Parsons

*Editorial and Design:*

Pauline Wingate, David Young, Marilyn David,  
Natasha Djuk, Anne Heat, Sandra Hosking,  
Rita Jacobs, David Kerby, Anita Kogan,  
Susan McCabe, Pamela Poulter, Tony Selina,  
Pat Thomas, Michael Tout

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# Contents

<b>Introduction</b>	<b>9</b>
<b>A-Z</b>	<b>11</b>
<b>Energy Resources Atlas</b>	
<i>Map 1:</i> World Energy Consumption in Relation to Population Distribution	199
<i>Map 2:</i> World Energy Production and Consumption	200
<i>Map 3:</i> World Energy Consumption per Capita	201
<i>Map 4:</i> World Energy Consumption and Gross Domestic Product (GDP)	202
<i>Map 5:</i> Changes in Energy Consumption since 1950	203
<i>Map 6A:</i> World Coal Reserves and Trade Movements	204
<i>Map 6B:</i> Coal Reserves in Europe	205
<i>Map 6C:</i> Coal Reserves in North America	206
<i>Map 6D:</i> Coal Reserves in the Middle East, USSR and Asia	207
<i>Map 7:</i> World Solid Fuel Production and Consumption	208
<i>Map 8:</i> World Petroleum Reserves, Refining Capacity and Trade Movements	209
<i>Map 9:</i> World Petroleum Production and Consumption	210
<i>Map 10A:</i> Oil and Gas Fields in the North Sea	211
<i>Map 10B:</i> Oil and Gas Fields in North America	212
<i>Map 10C:</i> Oil and Gas Fields in South America	213
<i>Map 10D:</i> Oil and Gas Fields in the Middle East	214
<i>Map 10E:</i> Oil and Gas Fields in Asia	215
<i>Map 10F:</i> Oil and Gas Fields in Australasia	216
<i>Map 10G:</i> Oil and Gas Fields in Africa	217
<i>Map 10H:</i> Oil and Gas Fields in Europe	218
<i>Map 10I:</i> Oil and Gas Fields in USSR	219
<i>Map 11:</i> World Natural Gas Production and Consumption	220
<i>Map 12:</i> World Natural Gas Reserves and Trade Movements	221
<i>Map 13:</i> World Deposits of Oil Shales and Tar Sands	222
<i>Map 14:</i> World Fossil Fuel Production and Consumption	223
<i>Map 15:</i> World Nuclear Power Production and Installed Capacity	224
<i>Map 16:</i> Uranium Deposits and Production	225
<i>Map 17:</i> Average Annual Distribution of Solar Radiation and Location of Potential Solar Sites	226
<i>Map 18:</i> World Hydroelectric Production and Installed Capacity with Plant Locations	227
<i>Map 19:</i> World Production of Wood and Consumption as Fuel	228
<i>Map 20:</i> World Distribution of Forest Areas	229
<i>Map 21:</i> Areas of Exploitable Geothermal Activity	230
<i>Map 22:</i> Possible Locations for Ocean Thermal Energy	231
<i>Map 23:</i> World Tidal Energy Sites	232
<i>Map 24:</i> Annual Wave Energy in Specific Sea Areas	233

## Statistical Appendices

### Appendix 1

Table 1: World Coal Production 1966-76	237
Table 2: World Solid Fuels Consumption (Coal, Peat, Lignite) 1966-76	238
Table 3: Natural Gas Reserves at the end of 1976	239
Table 4: World Natural Gas Consumption 1966-76	240
Table 5: World Oil Production 1966-76	241
Table 6: World Oil Consumption 1966-76	242
Table 7: Per Capita Consumption of Petroleum Products, 1976	243
Table 8: World Primary Energy Consumption 1966-76	244
Table 9: World Energy Production by Region 1950 and 1975	245
Table 10: World Energy Production by Region 1955, 1965 and 1975	246
Table 11: World Energy Consumption 1956, 1966 and 1976	247
Table 12: Nuclear Installed Capacity 1960-77	248
Table 13: Nuclear Power Growth Estimate 1978-2000	249
Table 14: Uranium Production (World; excluding USSR, E Europe and China)	250

### Appendix 2

Table 1: Conversion Tables	251
Table 2: Calorific Equivalents – Conversion Factors	252
Table 3: Approximate Calorific Equivalents for Conversion into Million Tonnes of Oil	253
Table 4: Approximate Calorific Values for Different Petroleum Products	254
Table 5: Approximate Calorific Values for Solid Fuels	254

### Appendix 3

Table 1: Geological Timescale	255
Table 2: The Age of Coal Resources of the World	256

### Appendix 4

Table 1: Classification of Crude Petroleum and its Components	257
Table 2: Natural and Manufactured Hydrocarbons derived from Petroleum	258



# Introduction

*The World Energy Book* is intended as a comprehensive reference guide to energy sources, energy related terminology, economics and all factors related to the search for, extraction of, production and utilization of the major and alternative sources of energy.

There are three main sections of the book, an A-Z containing some 1000 terms and definitions, the *Energy Atlas* and the *Statistical Data Section*.

## A-Z

The text in this section is presented in the form of alphabetically ordered entries (under bold entry headings) to enable immediate and easy reference to be made. Cross-referencing (italics) is used throughout to direct the reader to related subjects if he wishes to delve further. Many other cross-references will be isolated under other related entries so that the inquisitive reader will discover a network of facts stemming from his original inquiry. Additionally, further data can often be pin-pointed in the atlas and statistical sections.

Although primary chemical, primary physical, secondary chemical, secondary physical and nuclear sources of energy are not headings under which energy sources are listed in the A-Z, some idea of the extent of the terminology included can be gained from the subjects listed below under these headings.

### Primary chemical sources of energy

Solid fuels (coals, peat), petroleum/crude oil, oil shale, bituminous sands/tar sands, natural gas and photosynthates (cellulose and wood). Also included (where relevant): origins and nature, the state of relevant technology, methods of discovery, extraction (or growth) and production, research and development, geology, preparation, refining and extraction, transportation or transmission, conversion to heat, storage, energy economics and analysis, uses, the importance of each source to the overall energy picture, environmental and health factors, consumption, production and reserves, energy equivalents and conversion factors. (These last statistical areas are briefly covered in the A-Z then reference is made to the extensive tables in the statistical section.)

### Primary physical sources of energy

Solar, hydroelectric, geothermal, wind, tidal, waves, and ocean thermal gradients. Also includes: nature and origins, climatic and geological conditions, harnessing technology and developments, uses, advantages and disadvantages, potential uses, economic and environmental considerations, legal factors. Production, consumption, energy equivalents and conversion factors and the proportion of the overall energy supply are dealt with by reference to the statistical section.

### Nuclear sources of energy

Nuclear energy introduction, nature, nuclei and the release of energy. *Fission energy*: conditions of controlled reaction, heat transfer and transmission, research and development, energy equivalents and conversion factors, environmental and economic factors, radiation hazards, world demand, production and distribution, the proportion of total energy supply. *Nuclear reactors*: burner reactors, breeder reactors, present state of technology, future prospects and risks, nuclear materials. *Fission fuels*: uranium, thorium, plutonium, ancillary nuclear materials (including deuterium, zirconium), location/extraction (if applicable) and isolation, reprocessing, forms in use, future importance of each fuel. *Fusion* (thermonuclear energy): nature, importance, economic and environmental factors, thermonuclear reactors, laser reactors, safety and development. *Fusion fuels*: tritium, lithium, deuterium, physical properties; reserves, extraction and isolation, potential uses.

### Secondary chemical sources of energy

Alcohols, manufactured gases, synthetic petroleum, waste materials, sewage, heat of fermentation, acetylene, hydrogen and hydrogen economy. Also included: nature and origins, present use and potential value, conversion factors, the state of technology, economic and environmental considerations, production and consumption.

### Secondary physical sources of energy

Fuel cells, photoelectric energy, high temperature boilers, pumped storage, electrolysis, magnetohydrodynamics; technical, economic and environmental factors, conversion

## **Introduction**

factors, energy value and specific advantages and disadvantages.

### **The Energy Resources Atlas**

The atlas section is cross-referred to from the A-Z. It covers certain information which, as in the statistical section, is beyond the range of the A-Z. Maps provide detailed information on, for example, the location of oil and gas fields offshore and onshore in North America, South America, the Middle East and the North Sea; on coal, tar sands, oil shales, uranium and other fuel deposits; on possible tidal energy, sea wave energy and ocean thermal gradient

sites; on geothermal areas, solar energy levels, hydroelectric sites; and on data on energy production, consumption and trade. The atlas section is also able to illustrate geographical distribution and movement of fuel sources.

### **Statistical Appendices**

This section comprises tables, classification scales and conversion charts which provide statistical background information relating to all the present-day energy sources and some of the alternative sources. This section is cross-referred to and from the A-Z and atlas sections.

# A

## absolute scale of temperature

A scale of temperature based on the concept of an absolute zero of temperature, ie a point at which atoms and molecules possess no kinetic energy and at which an ideal gas would exert zero pressure. In practice, temperatures very close to absolute zero have been attained, and at these very low temperatures interesting physical phenomena such as *superconductivity* have been observed.

On the *centigrade scale* absolute zero is calculated to be  $-273.15^{\circ}$  (approx) and on the absolute scale of temperature this point corresponds to zero degrees of temperature. Degrees absolute are commonly referred to as degrees Kelvin ( $^{\circ}\text{K}$ ) and the general relationship between degrees Kelvin and degrees centigrade is:

$$^{\circ}\text{K} = ^{\circ}\text{C} + 273.15.$$

## absorption

In chemistry, the process in which one substance is taken up by another or penetrates it. Also the giving of energy, eg heat energy, to an insulating material by electromagnetic waves.

Absorption has many applications in industry. For example, by applying an absorption process to *wet gas* the higher *hydrocarbons* can be separated to provide a *dry gas* suitable for use as a fuel or *chemical feedstock*. The wet gas is passed through an absorption tower under slight pressure and the higher hydrocarbons are absorbed by a *light gas oil* flowing against it. The solvent gas oil is then heated and the dissolved products removed by steam.

See also *adsorption*.

## absorption cycle heat pump

A particular type of *heat pump* which exploits the latent heat of vaporization of a working fluid to transport heat from a low temperature source to a high temperature sink. Compression of the working fluid is achieved by absorption in a liquid or solid. This type of heat pump is used for gas-powered refrigerators and for *solar cooling*.

See also *refrigeration*.

## absorption gasoline

Natural gasoline obtained by *absorption* from *wet gas*. The

gasoline is extracted from the *absorption oil* (used to dry the gas) by *distillation*.

## absorption oil

A petroleum or coal tar oil that is used to absorb heavy components from a gas stream, as in the recovery of natural gasoline from *wet gas*.

## abundance ratio

In a mixture of *isotopes*, the ratio of the number of *atoms* of one isotope to the total number of atoms present.

## accelerator

A machine used to accelerate charged nuclear particles to very high energies. During the early 1930s accelerators using *protons* and *deuterons* were first employed to investigate nuclear reactions and this subsequently led to the discovery of *neutrons* and nuclear *fission*.

## accumulator

Also known as a storage battery. An *electric cell*, or an assembly of such cells, that is capable of storage. An accumulator can store energy on charging and release energy on discharging.

## acetylene

The usual term for the simplest member of the *alkyne* group of *hydrocarbons*, more correctly termed ethyne, and having the molecular formula  $\text{C}_2\text{H}_2$  ( $\text{HC}\equiv\text{CH}$ ). It is a gas at room temperature and atmospheric pressure. Acetylene may be manufactured from natural gas or petroleum feedstocks by high temperature cracking or partial oxidation and from coal via carbide production. Acetylene is used as a *chemical feedstock* and has a widespread, if small scale, use as a fuel employed in gas welding, the gas having a high calorific value of  $1455 \text{ Btu/ft}^3$  ( $54.2 \text{ MJ/m}^3$ ).

Acetylene has a high *energy requirement* for manufacture. This is largely because of the energy required to form the triple carbon-to-carbon bond of the molecule. Also acetylene prepared from carbide tends to contain impurities and therefore has to be cleaned before further conversion.

## acid gas

Natural gas containing *hydrogen sulphide* is usually referred to as acid gas or sour gas. The term is also applied to gas containing a large proportion of carbon dioxide. Gas from the Lacq field in France contains 15 per cent hydrogen sulphide by volume, while gas from Retiden in Germany contains 18 per cent carbon dioxide by volume.

Hydrogen sulphide present in small amounts can be removed by washing with a strong alkali (eg 10 per cent aqueous solution of NaOH). If the hydrogen sulphide is present in large amounts, it is more economical to use a regenerative process in which the hydrogen sulphide is absorbed in an *amine*, such as mono- or di-ethanolamine. Hydrogen sulphide is an undesirable impurity in any fuel or feedstock since it causes corrosion of plant and pollution when finally burnt. Carbon dioxide may be removed by *absorption* in an aqueous alkali.

Acid gases can be an important source of *sulphur*. Sulphur can be generated from hydrogen sulphide by partial *oxidation* with air, using a *bauxite catalyst*.

## acidizing

Method of stimulation of *petroleum* wells by injecting hydrochloric acid into the oil-bearing formation. The acid enlarges the porous passages to allow the oil to flow through.

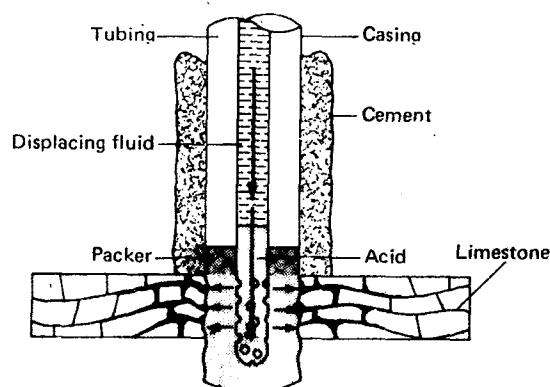
## actinide series

The group of elements with *atomic numbers* between 89

and 103. They are named after the first member of the series actinium.

The first four members of the series (*actinium*, *thorium*, *protactinium* and *uranium* and possibly also *plutonium*) occur naturally on earth: the remainder have been produced by nuclear reactions, either in nuclear reactors or in particle accelerators.

All the actinides are radioactive, and none of them has any stable isotopes.



Outline of the acidizing process

## activated carbon

A form of amorphous *carbon* characterized by a very large surface area per unit volume, approximately 1,000,000 m<sup>2</sup>/kg, due to its porous structure, and capable of adsorbing considerable quantities of matter. Also known as activated

Element	Symbol	Atomic number	Atomic weight*	Earthly abundance (ppm)	Present and potential uses:
Actinium	Ac	89	(227)	$3 \times 10^{-10}$	Neutron source
Thorium	Th	90	(232)	11.5	Gas mantles: potentially important fission power source.
Protactinium	Pa	91	(231)	$8 \times 10^{-7}$	Important only as research material
Uranium	U	92	(238)	4	Important fission power source; also used in chemical analysis and photography to small extent
Neptunium	Np	93	(237)	—	Component in neutron detection instruments
Plutonium	Pu	94	(244)	—	Important fission power source (both in reactors and as a portable power source, eg heart pacemakers)
Americium	Am	95	(243)	—	Used in thickness gauges in float glass manufacture
Curium	Cm	96	(247)	—	Potentially useful portable power source
Berkelium	Bk	97	(247)	—	No commercial or technical use at present
Californium	Cf	98	(251)	—	Important neutron source in moisture gauges; also used for well logging and neutron activation analysis
Einsteinium	Es	99	(254)	—	Presently available only in minute amounts
Fermium	Fm	100	(257)	—	Presently available only in minute amounts
Mendelevium	Md	101	(258)	—	Presently available only in minute amounts
Nobelium	No	102	(255)	—	Presently available only in minute amounts
Lawrencium	Lr	103	(256)	—	Presently available only in minute amounts

\* ( ) Mass No of longest lived isotope

## Actinide series

charcoal, it is obtained from a variety of carbonaceous materials, among them *wood, petroleum coke, peat, coal* and *bones*. Activated carbons for decolorizing are made from sawdust or *lignite*, while those used for *adsorption* of vapours are best made from briquetted coal or *charcoal*.

The most widely used method of activation is treatment with air, steam or carbon dioxide at a high temperature (approximately 800°-900°C). Activated carbon is used to purify gases (eg the removal of heavy components from *wet gas*), and liquids, (eg the purification of water supplies and pharmaceutical preparations).

### activation

1. The process by which certain molecules in a body acquire an amount of energy, called the *activation energy*, above the average energy of that body of molecules. The process of activation is a necessary initial step in reactions between molecules, and the magnitude of the activation energy for a reaction is an important determinant of the rate of the reaction.

2. Rendering substances (ie their nuclei) radioactive by neutron bombardment. The activation process can be used as a sensitive method of chemical analysis for the detection of trace quantities of elements.

### activation energy

In chemistry, the energy that must be given to the reactants to enable a reaction to take place. The concept of an activation energy, or 'energy barrier', is applicable to many other physical processes. The rate of a process is related to the magnitude of the energy barrier, and to the temperature.

### activity

A numerical parameter characteristic of the intensity of radiation emitted by a *radioactive isotope*.

The rate of breakdown of such an isotope is proportional to the amount present in a sample, ie:

$$\frac{dn}{dt} = -kn$$

(where n is the number of nuclei of the isotope present).

The constant of proportionality, k, is known as the activity of the isotope, and is related to the *half-life*,  $t_{1/2}$ , by the formula:

$$k = \frac{\ln 2}{t_{1/2}}$$

### additives

In *petroleum* technology substances added to fuels to improve their combustion characteristics or other properties. The term is also used to describe any substance added to a product with the purpose of enhancing its usefulness.

Some representative additives to fuels are detailed below.

Concentrations of additives in fuels range from one or two to several hundred parts per million. Many are now essential ingredients of *gasolines* and other motor fuels.

Additive	Function
Anti-knock compounds	Reduce susceptibility to detonation
Scavengers	Remove combustion products of anti-knock compounds
Anti-icing agents	Reduce icing in carburettor
Antioxidants	Enhance storability of fuel
Upper cylinder lubricants	Lubricate upper cylinders and pistons, and control inlet system deposits
Dyes	Indicate visually type and grade of gasoline

Additives to automotive gasoline

Additive	Function
Anti-icing agents	Prevent icing at altitude and suppress growth of bacteria and fungi in fuel
Anti-static additives	Decrease resistivity of fuel and so reduce hazard of sparking under high flow rate conditions
Antioxidants	Prevent formation of gums and coke in fuel lines and nozzles
Corrosion inhibitors	Reduce rust formation in fuel. Copper chelating agents are also used to suppress corrosion by this metal

Additives to aviation jet fuel

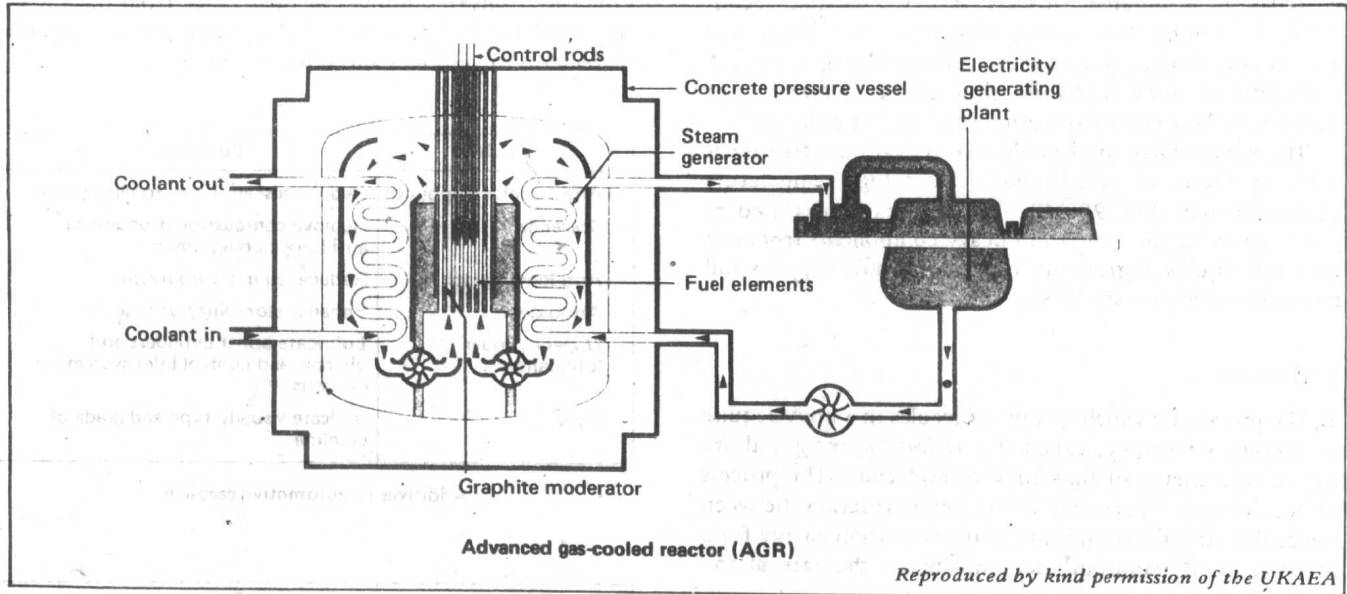
Additive	Function
Cetane improvers	Increase Cetane number
Detergents	Maintain fuel injection nozzle cleanliness
Rust inhibitors	Suppress fouling of injection system by rust
Antioxidants	Enhance storability of fuel
Pour-point depressants	Lower temperature at which a fuel will flow readily through pipe

Additives to diesel fuel

### adsorption

The adhesion of the molecules of one substance, in the gaseous or liquid phase, to another substance in the solid phase, resulting in a relatively high concentration of the adsorbed component at the surface.

The concentrating effect of adsorption is thought to be an important factor in the heterogeneous catalysis of



chemical reactions and, as such, adsorption plays an important part in the energy industries. The phenomenon is also exploited in the removal of high boiling point *hydrocarbons* from *wet gas* by passing the gas over particles of *activated carbon*. Adsorption is a surface phenomenon and the very high surface area of activated carbon enables significant quantities of the hydrocarbons to be retained. The adsorbed hydrocarbons can be subsequently recovered by passing steam over the saturated adsorbent, so regenerating the carbon for further use.

### advanced gas-cooled reactor (AGR)

A type of nuclear reactor in which heat extraction is by carbon dioxide gas under pressure (40 atmospheres at 634°C). The heat from the gas is transferred to water in a heat exchanger and converted into steam for a *turbogenerator*. The design specifies a heat output of 1494MWt giving about 621MWe with an efficiency of 41.6 per cent. The fuel is *uranium dioxide* pellets, 2 per cent enriched, clad in thin stainless steel. The moderator is *graphite*.

The AGR was chosen for the second generation of gas-cooled reactors in the UK, but problems have been encountered in their construction. Higher gas temperatures leading to more efficient production of electricity are achieved by using uranium dioxide, which melts at 2800°C, as fuel rather than the *uranium metal* of the *Magnox reactor*. Also the *burn-up* of uranium dioxide is greater, 18,000 megawatt-days per tonne.

### advance mining

A method of underground mining in which extraction proceeds from the base of the shaft outwards towards the boundary of the deposit.

#### Advanced gas-cooled reactor data\*

Peak power density	4.5 kW/l
Proposed heat output	1494MWt
Proposed electrical output	621MWe
Proposed efficiency	41.6%
Fuel	Uranium oxide pellets, 2% enriched, clad in stainless steel
Weight of fuel	113.7 tonnes
Fuel burn-up	18,000MWD/te
Moderator	Graphite
Coolant	Carbon dioxide gas
Coolant pressure	40 atmospheres
Coolant outlet temperature	634°C
Refuelling	On load

\*Data based on Hinkley Point B (UK)

### aerodynamic uranium enrichment

The enrichment of uranium fuels by the aerodynamic separation and concentration of the required *isotopes*.

See also *uranium enrichment*.

### aerogenerators

General name given to devices which extract useful energy from wind.

See also *wind energy*.

### afterdamp

The major gaseous product formed by the combustion of *coal gas*. It is nonflammable, occurs in coal mines after an explosion and comprises mainly *carbon dioxide*.

See also *black damp*; *firedamp*; *white damp*.

**afterheat**

The heat from fission products remaining in a nuclear reactor after shut down.

**AGR**

Initials for *advanced gas-cooled reactor*.

**Airco-Hoover process**

A method of 'sweetening' gasoline by means of alkali and water washes, followed by passage through a diatomaceous clay/copper chloride catalyst. The process converts corrosive and troublesome mercaptans to the less harmful disulphides.

**air cycle heat pump**

A particular type of *heat pump* which uses air as the working fluid.

See also *refrigeration*.

**air gas**

Alternative name for *producer gas*.

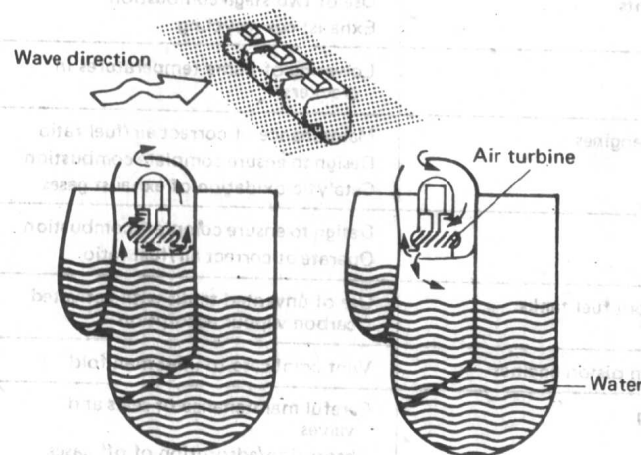
**air pollution**

The presence in the atmosphere of contaminants such as dust, fumes, gas or smoke in such quantities and of such a nature as to be injurious to plant, animal and human life or an unreasonable interference with people's welfare and property.

Air pollution arises from many energy producing and processing technologies, from the burning of wood to the operation of nuclear power stations.

See the table *Sources of Pollution and Means of Control* (pages 16-17) which briefly summarizes the major air pollution sources associated with energy production and consumption.

See also *environmental effects; sulphur emissions*.



Sectional views of two air pressure ring units together with part of a row of units

**air pressure ring buoy**

A *wave energy* device which tilts backwards and forwards with the movement of waves thus distributing water inside from compartment to compartment and back again. Air inside is made to flow by the changing distribution of water and this air movement operates an air turbine within the buoy.

The air pressure ring buoy was initially developed from Japanese studies on floating breakwaters.

**alcohol**

The common name for *ethanol*,  $C_2H_5OH$ . In chemistry the term is applied to a large number of organic compounds containing the hydroxyl  $-OH$  group: the simplest alcohol is *methanol*  $CH_3OH$ .

Both methanol and ethanol are manufactured from *hydrocarbon* sources: methanol from *natural gas* and ethanol from *ethylene* obtained from *petroleum*. Ethanol is additionally obtained by *anaerobic fermentation* of natural products, usually *carbohydrates*. Although such production is largely used for human consumption as beverages, it has been suggested that fermentation alcohols (both ethanol and methanol) could be important sources of fuel and *chemical feedstock* when oil becomes scarce.

**alcoholic fermentation**

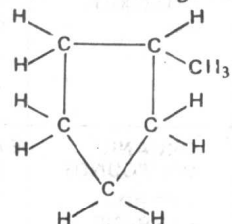
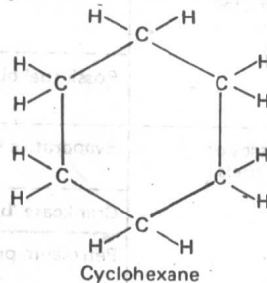
Also known as *anaerobic fermentation*, the process by which certain yeasts decompose sugars in the absence of oxygen to form *alcohols* and *carbon dioxide*, eg the production of *ethanol*, wine and beer from *carbohydrate* sources.

**algae**

An important division of non-flowering plants (thallophytes) having a considerable size range, including *seaweed* and unicellular plants. The majority of the *photosynthesis* in the sea is due to algae which play an important part therefore in the reoxygenation of the atmosphere and the overall energy cycle. Algae provide a possible alternative energy source as a *cellulose* material.

**alicyclic hydrocarbons**

Hydrocarbons in which the carbon skeleton is arranged in



Typical alicyclic hydrocarbons  
(These are both *cycloalkanes*.)



### Air Pollution: Sources of Pollution and Means of Control

Pollutant	Produced by:	Important Sources	Control Methods
<b>SMOKE</b>	Combustion of any fuel with high-ash content	Coal and oil-fired power plant using high-ash fuel	Use of low-ash fuel Electrostatic precipitators on stacks
		Open fires burning coal	Use of smokeless solid fuels (manufactured)
	Incomplete combustion of hydrocarbon fuel	Diesel engines	Careful maintenance and adjustment
		Refuse incineration	After burners to complete combustion Filters and precipitators on stacks
<b>DUST</b>	Handling of solid fuel	Coal mining	Water spraying
		Coal processing	Precipitation and/or filtration
<b>HYDROGEN SULPHIDE AND OXIDES OF SULPHUR SO<sub>x</sub></b>	Burning of any fuel containing sulphur SO <sub>x</sub>	Coal and oil-fired power plant using sulphur-containing fuel	Use of low-sulphur fuel Desulphurizing fuel before use Dispersion by use of high stacks Catalytic oxidation or reduction Absorption in dolomite or limestone Wet scrubbing of stack gases
		Domestic and industrial heaters and boilers	Use of low-sulphur or desulphurized fuel
		Petroleum refineries	Desulphurization prior to combustion or cracking Chemical absorption Catalytic oxidation or reduction
		Refuse incineration	Chemical absorption or wet scrubbing of flue gases
	Release of natural sources H <sub>2</sub> S and SO <sub>x</sub>	Geothermal energy plants	Control of and absorption of sulphur oxides from exit gases
<b>HYDROGEN SULPHIDE AND MERCAPTANS</b>	Processing of sulphur-containing hydrocarbons	Petroleum processing	Wet scrubbers Catalytic oxidation or reduction
<b>OXIDES OF NITROGEN NO<sub>x</sub></b>	Burning of any fuel in air at high temperature	Internal combustion engines	Lowering of flame temperatures Restricting of oxygen supply by enriching fuel/air mixture After burning of exhaust gases in combustion chamber Catalytic re-conversion to N <sub>2</sub> and O <sub>2</sub>
		Fossil fuel power plants	Use of two-stage combustion Exhaust gas recycling
		Petroleum processing	Lowering of flame temperatures in crackers
<b>CARBON MONOXIDE CO</b>	Burning of carbonaceous fuel with restricted oxygen supply	Internal combustion engines	Maintenance of correct air/fuel ratio Design to ensure complete combustion Catalytic oxidation of exhaust gases
		Fossil fuel burners	Design to ensure complete combustion Operate at correct air/fuel ratio
<b>ORGANIC COMPOUNDS HYDRO-CARBONS</b>	Evaporation/losses of hydrocarbon fuels	Evaporative losses from fuel tanks	Use of unvented tanks with activated carbon vapour adsorption
		Crankcase 'blowby' in piston engines	Vent crankcase to inlet manifold
		Petroleum processing	Careful maintenance of seals and valves Absorption/adsorption of off gases Cryogenic removal from exit streams

Pollutant	Produced by:	Important Sources	Control Methods
<b>ORGANIC COMPOUNDS</b> <b>HYDRO-CARBONS</b>	Incomplete combustion of hydrocarbon fuels	Internal combustion engines	Combustion chamber design to ensure complete combustion Use of weak fuel/air mixture Catalytic converters to oxidize exhaust gases
<b>ORGANIC COMPOUNDS</b> <b>ALDEHYDES</b>		Internal combustion engines	Maintenance of correct air/fuel ratio Catalytic oxidation of exhaust gases
<b>BENZO PYRENE</b>		Internal combustion engines	Use of gasolines low in aromatic content
<b>LEAD</b> (in particulate form)	Burning of fuels containing lead-based anti-knock additives	Internal combustion (spark ignition) engines	Filtration of exhaust gases Use of low lead fuel (with high aromatic content) Use of lower compression ratios
		Refuse incineration	Efficient precipitation of fly/ash
<b>HYDROGEN CHLORIDE</b>	Burning of hydrocarbon fuel containing chlorine	Refuse incineration (source of chlorine mainly PVC)	Wet scrubbing of exit gases
<b>RADIOACTIVE NUCLIDES:</b> Kr-85 Kr-87 Kr-88 Xe-133 Xe-135 Xe-138 H-3  Kr-85 H-3	Fission products of radioactive decay	Leaking fuel rods in nuclear reactors	Rapid detection and removal of leaking fuel rods (gas cooled reactors) Adsorption of emissions on activated carbon to delay release beyond several half-lives of decay products Detention of gaseous emission products in gas storage (pressurized water reactors)
		Fuel reprocessing	Cryogenic removal Adsorption in activated carbon
<b>Ar-41</b>	Product of neutron activation of argon in air	Nuclear reactors using air cooling in high-neutron areas	Cryogenic removal Adsorption in activated carbon
<b>Ra-226</b> <b>Ra-228</b> <b>U-238</b> <b>Th-230</b> <b>Th-232</b> <b>K-40</b>	Burning of fossil fuels	Fly-ash from fossil-fuelled power plants	Efficient precipitation of fly/ash Dilution of effluent by use of tall stacks
<b>HEAT</b>	Use of any non-ambient energy source	Fossil-fuelled and nuclear power stations Geothermal power plants	Dispersion of power plant reduces local effects of thermal pollution Reduction in waste heat output in energy conversions Effective mixing of waste heat streams reduces ecological effects at a local level

one or more closed rings, but without the characteristic structure of alternating bonds that leads to aromatic properties. (The word is an abbreviation of 'aliphatic cyclic' and the compounds are so called because of their chemical similarities with *aliphatic hydrocarbons*.)

Alicyclic hydrocarbons occur naturally in crude oils as a mixture of many different molecular species, generally known as *naphthenes*. Examples include cyclohexane and methylcyclopentane.

See also *aromatic hydrocarbons*.

## aliphatic hydrocarbons

*Hydrocarbons* in which the carbon skeleton is in the form

of an open chain, as opposed to the *alicyclic hydrocarbons* and the *aromatic hydrocarbons* in which the carbon atoms form closed rings. They are the major constituents of petroleum.

## alkaline accumulator

Also known as alkaline storage cell or battery. A secondary *electric cell* in which the electrolyte consists of an aqueous solution of an alkali, usually potassium hydroxide.

See also *nickel-cadmium accumulator*; *nickel-iron accumulator*.